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Natural disasters and communicable diseases in the Americas: contribution of veterinary public health

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Summary

The consequences of natural disasters on the people living in the Americas are often amplified by socio-economic conditions. This risk may be increased by climate-related changes. The public health consequences of natural disasters include fatalities as well as an increased risk of communicable diseases. Many of these diseases are zoonotic and foodborne diseases. The aim of this article is to provide an overview of the importance of natural disasters for the Americas and to emphasise the contribution of veterinary public health (VPH) to the management of zoonotic and foodborne disease risks. An analysis was conducted of natural disasters that occurred in the Americas between 2004 and 2008. Five cases studies illustrating the contributions of VPH in situations of disaster are presented. The data shows that natural disasters, particularly storms and floods, can create very important public health problems. Central America and the Caribbean, particularly Haiti, presented a higher risk than the other areas of the Americas. Two priority areas of technical cooperation are recommended for this region, namely: reducing the risk of leptospirosis and other vector-borne disease outbreaks related to floods and hurricanes and improving food safety. The contribution of different disciplines and sectors in disaster preparedness and response is of paramount importance to minimise morbidity and mortality.

Keywords

Americas, Communicable disease, Natural disaster, Preparedness, Veterinary public health, Zoonosis.

Disastri naturali e malattie trasmissibili nelle Americhe: un contributo della Sanità Pubblica Veterinaria

Riassunto

Le conseguenze dei disastri naturali sugli abitanti dell'America del Sud e dell'America del Nord sono spesso amplificate dalle condizioni socio-economiche. Questo rischio aumenta anche in relazione ai cambiamenti climatici. Le conseguenze sulla salute pubblica di un disastro naturale comprendono non solo vittime umane ma anche un maggior rischio di malattie trasmissibili, principalmente zoonosi e o patologie di origine alimentare. L'obiettivo di questo articolo è quello di fornire una panoramica sulla rilevanza delle calamità naturali nelle Americhe e porre l'enfasi sul contributo della Sanità Pubblica Veterinaria (SPV) nella gestione del rischio connesso alle zoonosi e alle malattie di origine alimentare. A questo scopo è stata condotta un'analisi delle caratteristiche delle calamità naturali verificatesi nelle Americhe tra il 2004 e il 2008; vengono quindi presentati cinque casi-studio

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che illustrano i contributi di SPV in situazioni di calamità naturale. L'entità dei dati in termini di numero di casi e vittime mostra che i disastri naturali, in particolare tempeste e inondazioni, possono creare problemi estremamente rilevanti di salute pubblica. L'America Centrale e i Caraibi, in particolare Haiti, presentano un rischio più elevato rispetto alle altre regioni delle Americhe . Sono due le aree prioritarie di cooperazione tecnica indicate per questa specifica regione, ovvero la riduzione del rischio di focolai di leptospirosi e malattie trasmesse da vettori correlate alle inondazioni e agli uragani e il miglioramento della sicurezza alimentare. Il contributo di diverse discipline e settori impegnati nell'attività di preparazione e risposta alle catastrofi è fondamentale per minimizzare la morbidità e la mortalità.

Parole chiave

Americhe, Disastro naturale, Malattie trasmissibili, Preparazione, Sanità Pubblica Veterinaria, Zoonosi.

Introduction

Natural disasters have been a major public health problem throughout the history of humankind. They are defined as catastrophic events with atmospheric, geological or hydrological origins and include earthquakes, volcanic eruptions, landslides, tsunamis, floods and drought (79). Perhaps the most famous example of a natural disaster that had tremendous human consequences is the eruption of Mount Vesuvius in 79 AD, which led to the destruction of Pompeii (19). Major natural disasters of the modern era include the Great Lisbon Earthquake of 1755, which caused over 60 000 deaths. A devastating example in recent history is the Indian Ocean tsunami of 2004, which killed 226 000 people and destroyed thousands of villages throughout South-East Asia (78) and the Haiti earthquake in January 2010 which is estimated to have killed over 222 000 people and directly or indirectly affected almost one third of the population of Haiti (63).

The region of the Americas constitutes one of the regions of the world that is most exposed to natural disasters (41), due in part to its geographic conditions. It sits on five tectonic plates, which cause intense seismic activity. The Caribbean lies in the path of tropical storms and hurricanes and South America has more active volcanoes than any other continent (13). Examples of major natural disasters in the region include the Huascaran Mountain landslide in 1970 in Peru, which engulfed about 70 000 people in a matter of minutes (28), the Mexico City earthquake of 1985, which caused approximately 5 000 casualties (54, 83), Hurricane Mitch of 1998, which devastated Central America and killed over 10 000 people (46) and the Haiti earthquake mentioned above.

Although the region experiences natural disasters due to its geographical vulnerability, the human impact of these disasters is often amplified by socio-economic vulnerability. In Latin America and the Caribbean, approximately 195 million people live in poverty, which is defined as earning less than US$2 a day (16). This widespread poverty contributes to the region's vulnerability to natural disasters as the poor are often relegated to living in hazardous areas and low-quality dwellings (13). Indeed, 80% of the population of the Americas reside in urban areas, many of them in slums in large cities. Dense settlements and poor infrastructures in which these populations live make them particularly vulnerable to the impact of natural disasters.

The human impact of natural disasters can be enormous – these events overwhelm the local response capacity and affect the social and economic development of a region (13). Natural disasters disproportionately affect developing countries due to a lack of resources, infrastructure, and disaster-preparedness systems (69).

Disasters disrupt the functioning of a community, causing widespread human, material, socio-economic and environmental damages (64). The public health effects of a natural disaster include not only fatalities related to the trauma caused by the immediate event but, in certain circumstances, also increased risk of communicable diseases, population displacement, climatic exposure, lack of sanitation and destruction of health infrastructures (39).

The topic of infectious diseases following natural disasters has been studied and discussed for many years in all regions of the world (3, 29, 48, 49, 55, 56, 69, 70). Although the risk of communicable disease outbreaks in post-disaster situations is often overestimated, the transmission of certain endemic and epidemic-prone diseases can increase after a natural disaster (39). This elevated risk of transmission is associated primarily with population displacement and, more specifically, with the size, health status and living conditions of the population displaced by the disaster (79). Population displacement is often characterised by overcrowding, inadequate sanitation and poor access to health services, all of which create the potential for the spread of communicable diseases (18).

Many of the communicable diseases associated with natural disasters are related to veterinary public health (VPH). Two core domains of VPH are the control of zoonoses and food safety (40, 50, 57, 76), both of which are vital in the aftermath of a natural disaster. The displacement of wild and/or domestic animals near human settlements can increase human exposure to zoonoses (39). There is also an elevated risk of vector-borne diseases due to the disruption of vector control efforts and the proliferation of the vector population, especially after floods or heavy rainfall (35, 79). Natural disasters may also be accompanied by an increased incidence of animal and arthropod bites due to greater environmental exposure among displaced populations (53). Finally, there is a higher risk of foodborne disease after a natural disaster. Poor sanitation and lack of suitable conditions to prepare food have led to mass outbreaks of diarrhoea, dysentery, cholera, hepatitis A and typhoid fever in post-disaster situations (77).

Challenges of climate change and variability to the response of veterinary public health to disasters

Data from the United Nations International Strategy for Disasters Reduction's Center for Research on the Epidemiology of Disasters (UNISDR/CRED) show an increase in the number of natural disasters over the past 20 years (recorded disasters have doubled from approximately 200 to over 400 per year). Disasters caused by floods are more frequent and affect larger areas than they did 20 years ago (66). Many of these disasters are due to the increase of frequency and intensity of extreme weather events related to climate change and variability, such as heat waves, droughts, heavy rainfall, storms and expanded areas affected by droughts and floods (33). Climate-related extreme events have severe consequences on human and animal health, food and water safety and security, particularly for poor coastal and island communities and populations dependent on agriculture and natural resources.

Pathways through which climate change may have an impact on animal health, zoonoses and other VPH issues include the following:

- increase in the susceptibility of animals to disease
- increase of the range or abundance of vectors/animal reservoirs
- prolonged transmission cycles of vectors
- increased vulnerability of particular social groups and economic sectors due to extreme weather events and ecosystem stress
- impact on farming husbandry practices, including the use of veterinary drugs (the proliferation of zoonoses and other animal diseases may result in an increased use of veterinary drugs that could lead to increased and possibly unacceptable levels of veterinary drugs in foods (23, 59).

Zoonoses

In addition to the direct impacts of disasters and extreme weather events involving flooding on the spread and transmission of diseases from animals to humans, the risk of emerging zoonoses may increase due to climate-related changes. Climatic factors may affect the survival of pathogens in the environment, in vectors and carriers, changes in migration pathways and modifications of the ecosystem. For example, Rift Valley fever, West Nile fever and tick-borne diseases are animal diseases that have distribution patterns which will be strongly influenced by climate change and variability (20, 23).

Diseases transmitted by rodents may increase during heavy rainfall and flooding because of altered patterns of human-pathogen-rodent contact. There have been reports of flood-associated outbreaks of leptospirosis from a wide range of countries in Central and South America (17). Hantavirus pulmonary syndrome is an uncommon but sometimes fatal zoonotic disease that is linked to close contact between people and wild rodents (17). Table I presents the zoonotic agents that can be affected by climate change and their mode of transmission.

Foodborne and waterborne diseases

Following natural disasters, particularly those associated with floods, food may become adulterated by surface water that has been contaminated by sewage and waste water carrying pathogenic bacteria from sewer systems, septic tanks, animal farms and by toxic chemicals and environmental pollutants. Extreme rainfall facilitates water-borne disease outbreaks through piped water supplies or surface water.

Populations with poor sanitation infra-structures often experience increased rates of water- and foodborne diseases including hepatitis A, typhoid fever and diarrhoeal diseases, such as cholera, dysentery, norovirus infections and to the exposure to toxic chemicals through contaminated foods and water (32, 77).

After natural disasters, displaced populations suffer from extreme stress, malnutrition, diarrhoea, limited access to medical care, all of which contribute to ill health and increased

Table I
Selected examples of zoonotic agents that can be affected by climate change and their mode of transmission to humans

Agent	Zoonotic agent	Host	Mode of transmission to humans
Bacteria	*Salmonella*	Poultry and pigs	Faecal/oral
	Campylobacter	Poultry	Faecal/oral
	Vibrio spp.	Shellfish, fish	Faecal/oral
	Escherichia coli O157	Cattle and ruminants	Faecal/oral
	Anthrax *Clostridium*	Livestock and wild birds	Ingestion of spores through environmental routes, water, soil and feeds Associated with outbreaks of after droughts
	Leptospira	All farm animal species	Leptospira shed in urine contaminate pastures, drinking water and feed
Viruses	Hantavirus	Rodents	Aerosol route from rodents Outbreaks from activities such as clearing rodent infested areas and hunting
	Hepatitis E virus	Wild and domestic animals	Faecal-oral. pig manure is a possible source through contamination of irrigation water and shellfish
Parasites	Tapeworm		
	Cysticercus bovis	Cattle	Faecal-oral
	Trematodes		
	Fasciola hepatica	Sheep, cattle	Eggs are excreted in faeces
	Protozoa		
	Toxoplasma gondii	Cats, pigs, sheep	Cat faeces are a major source of infection Handling and consuming raw meat from infected sheep and pigs
	Cyptosporidium	Cattle, sheep	Faecal-oral transmission Waterborne
	Giardia	Cattle, cats, dogs	Faecal-oral transmission Waterborne

Sources: Food and Agriculture Organization (23) and Tirado *et al.* (59)

susceptibility to diseases. Food safety risks in the aftermath of natural disasters are mainly linked to unsafe food storage and cross-contamination from the environment and people during food handling and preparation. In displaced settlements, cooking may be impossible due to the lack of electricity, facilities or fuel.

Vector-borne diseases

The risk of flooding of human settlements from both a rise in sea level and increased heavy precipitation in coastal areas will possibly result in an increase in the number of people exposed to vector-borne diseases (e.g. malaria and dengue). Dengue is the world's most important vector-borne viral disease and is particularly prevalent in the Americas. High rainfall, flooding and high temperatures can lead to an increase in the transmission of dengue and drought can also be a cause if household water storage increases the number of suitable mosquito breeding sites (17).

Animal and food production systems

Natural disasters involving floods have a major impact on food and food production systems. Agricultural production may be adversely affected by flooding associated with natural disasters since crops can be contaminated with pathogens (77) and agriculture soils with environmental contaminants such as dioxins and polychlorinated biphenyls (PCBs) (61). Floods and changes in temperature and relative humidity may favour the growth of fungi that produce mycotoxins, for example in wheat, maize, rice and coffee, and may also increase the use of fungicides and the presence of residues in foods (23). Disrupted animal production infrastructures and damaged wastewater and sanitation systems may leak in surface waters, fishing grounds and aquaculture ponds, with the consequential risks of introducing viral, bacterial and parasitic diseases (77).

In the light of the above, the United Nations have defined a set of objectives aimed at mitigating the impact of disasters and enhancing preparedness.

The United Nations objectives for disaster management

Through the UNISDR, the objectives developed by the United Nations for disaster management are as follows:

- increase public awareness
- understand risk, vulnerability and disaster reduction globally
- obtain commitment from public authorities
- implement disaster reduction policies and actions
- stimulate interdisciplinary and inter-sectoral partnerships, including the expansion of risk reduction networks; and to improve scientific knowledge about disaster reduction.

Overall, the UNISDR aims at including disaster reduction as a key component in the sustainable development of communities, in order to reduce the human, social, economic and environmental losses caused by disasters (62, 65, 67, 68).

According to the Pan American Health Organization (PAHO), natural events constitute what is called a hazard. Vulnerability is defined as the susceptibility of a population or system to the effects of the hazard. In turn, risk includes both the number of hazards and the vulnerability of the population (human impact and infrastructure) (39) as shown below:

risk = hazard × vulnerability
hazard = natural events
vulnerability = susceptibility of a population or system (infrastructure).

In the Hyogo Framework for Action, the UNISDR defines different phases related to disaster actions, such as ensuring that disaster risk reduction is a national and local priority, identifying, assessing and monitoring disaster risks and enhancing early warning; using knowledge, innovation and education to build a culture of safety, reducing underlying factors and strengthening disaster preparedness for effective response at all levels (64).

The World Health Organization (WHO) is responsible for the health 'cluster' during disaster response. The PAHO is the WHO's regional office for the Americas. VPH activities

at PAHO have been ongoing for over 50 years, many of than related to emergencies.

VPH professionals apply multidisciplinary approaches that enable them to address the complex interactions between animal and human diseases and the environment. This unique multidisciplinary background allows VPH to play a major role in the development of preparedness and response plans to outbreaks, natural disasters and different types of emergencies and to coordinate actions among the health, agriculture and environmental sectors.

An analysis of the characteristics and impact of natural disasters on the countries of the Americas could provide relevant information to support technical cooperation for humanitarian action at national and international levels. It would provide a rational basis for decision-making in disaster preparedness, as well as provide an evidence base for setting priorities for technical cooperation related to this topic, including communicable diseases and the possible contribution of VPH.

The objective of this article is to provide an overview of the importance of natural disasters for the Americas and to link it to possible contributions of VPH professionals, focusing primarily on the control of communicable diseases, including some examples of VPH activities that support countries in their response to natural disasters.

This paper consists of three sections, as follows:

- an analysis of the major natural disasters in the Americas from 2004 to 2008, including case studies that illustrate the role of VPH in responding to natural disasters
- based on this analysis, a review of the impact of natural disasters in the Americas and the role of VPH in addressing these impacts
- recommendations to strengthen the involvement of VPH in the preparedness plans and management and response to natural disasters.

Materials and methods

Using data from the emergency events database (EM-DAT) (www.emdat.be) of the CRED, a WHO collaborating centre, events that occurred in the Americas between 2004 and 2008 were analysed. The types of natural disasters, the number of events in the region, the total number of affected populations and number of deaths were included in the analysis to review the spatial distribution of hazards, the major types of natural disasters affecting the region and their impact on human populations. Only information on natural disasters was included in the analysis. Definitions and classification of natural disasters correspond to those used by CRED (12). Although there are other databases with different criteria to define natural disasters, the data used was limited to that from the EM-DAT. For this reason, it is possible that other disasters occurred in the time period and were not captured by the database.

For the calculation of rates, population data for the Americas for the same time period were obtained from the PAHO Core Health Data System (44). To estimate mortality rates due to natural disasters, the countries and territories with less than 100 000 inhabitants were excluded from this analysis due to instability in the rates in small populations.

The maps were produced using the geographic information systems (GIS) ArcView-ArcEditor 9.3.1 and applying the Jenks Natural Breaks classification method. Since some countries had a value of zero as a total number of deaths and also as a mortality rate, the classification was manually modified creating a group with zero deaths. This resulted in the inclusion of these countries into a class of their own which was distinguished from those that had reported death events.

Five case studies are presented to illustrate the role of VPH in responding to the impacts of natural disasters. The data and information for these case studies was provided by PAHO national counterparts through internal reports and contributions from PAHO staff through technical cooperation in the related countries.

Results

Overview of natural disasters in the Americas

Spatial distribution of events

Between 2004 and 2008, 470 natural disaster events (hazards) were recorded with an average of 94 events per year, or one natural disaster every 4 days. Countries with the highest number of events per territorial area were the Dominican Republic, El Salvador, Haiti and Jamaica. Storms represented 40% of the events (with tropical storms, mostly hurricanes, responsible for 26% and floods 37%). In terms of human impact (vulnerability), the total affected population was approximately 48 million, with 15 896 deaths (40% of them in Haiti). Countries with the highest mortality rate caused by natural disasters were the Dominican Republic, Granada, Guatemala and Haiti. Haiti is clearly the highest priority country for disasters in the Americas.

Absolute numbers appear to reflect a relatively even distribution of events among the subregions (139 [29.6%] in North America, 129 [27.4%] in South America, 107 [22.8%] in the Caribbean and 102 [21.7%] in Central America). However, considering the enormous differences in size and population of each of the subregional territories, it can be suggested that the effective exposure to risk from natural disasters is much higher in the Caribbean and Central America.

For countries with ten or more events of natural disasters, selected information, including size in square kilometres, population and population living below the international poverty line are listed in Table II. Of particular interest in this list are countries such as Haiti (26 events), the Dominican Republic (15), Costa Rica (12), El Salvador (12), Jamaica (11) and Panama (10), all with territories of less than 100 000 km² located in the Caribbean and Central America.

Types of disaster

The disaster types that occurred most frequently were storms (190 events or 40.4%) and floods (170 events or 36.2%) (Table III). Other disaster types, each comprising less than 5% of the total number of events, included droughts (14 events), earthquakes (22 events), extreme temperatures (20 events), volcanic eruptions (14 events), wildfires (18 events) and others (22 events) (Fig. 1).

The most frequent subtype of storms are tropical cyclones (68.4% of storms) including hurricanes, which are most common in the Caribbean and Central America, extra-tropical cyclones (winter storms) with a few events in North America and local storms, such as thunderstorms, snowstorms/blizzards and tornadoes that occurred in different areas. During this period, 25 countries or territories reported one or more event of flooding. Countries that presented ten or more events of floods in the analysis were Brazil (13), Canada (10), Colombia (13), Haiti (12) and the United States (31). Flooding is a frequent disaster type in all subregions.

Considering that floods and tropical cyclones are the most frequent events, we can suggest that approximately 60% of the natural disasters in the region could potentially present a risk for water-related communicable diseases.

Human impact

The total population affected by a natural disaster, defined as 'the sum of injured, homeless and affected people requiring immediate assistance during a period of emergency, i.e. requiring basic survival needs such as food, water, shelter, sanitation and immediate medical assistance' during this period was reported to be approximately 48 million people. While there is no easily found data on morbidity during disasters, we can suggest that this population must have been vulnerable to communicable diseases, particular those living in shelters, due to lack of sanitation and compromised food safety.

During this period, approximately 23 million people (almost 48% of the total affected number of people) were affected by floods. Indeed, storms and floods caused the most fatalities (57.8% and 38.0% of all deaths, respectively) during the study period, followed by earthquakes (4.3%), which had a particularly high death toll in 2007.

Table II
Countries in the Americas presenting ten or more events of natural disasters: selected information

Country	Area (km^2)[a]	Total population (thousands) 2008[b]	Population below international poverty line ($2 a day, ppp) (%)[c]	No. of events	Total affected population 2004-2008[d]	No. of people killed 2004-2008[d]	Most frequent type of natural disaster	No. of events per territorial area (100 000)[e]
Argentina	2 780 403	39 934	7.3 (2006)	10	231 059	40	Flood (60%)	0.36
Bolivia	1 098 581	9 694	21.9 (2007)	12	1 050 680	168	Flood (33%)	1.10
Brazil	8 514 877	194 228	12.7 (2007)	23	3 479 071	506	Flood (57%)	0.27
Canada	9 984 670	33 170	...	19	13 700	11	Flood (63%)	0.19
Chile	756 096	16 803	2.4 (2006)	13	311 877	109	Flood (46%)	1.72
Colombia	1 141 748	46 741	27.9 (2006)	27	4 367 139	773	Flood (48%)	2.40
Costa Rica	51 100	4 534	4.3 (2007)	12	241 406	46	Flood (75%)	23.50
Cuba	109 886	11 265	...	15	3 578 970	34	Storm (73%)	13.70
Dominican Republic	48 671	9 904	12.3 (2007)	15	20 6476	903	Storm (67%)	30.80
El Salvador	21 041	6 953	13.2 (2007)	12	99 994	153	Flood (42%)	57.00
Guatemala	109 117	13 686	24.3 (2007)	12	681 155	1674	Flood (42%)	11.00
Haiti	27 700	9 751	...	26	936 456	6387	Storm (58%)	93.90
Honduras	112 492	7 246	29.7 (2006)	14	788 909	139	Storm (43%)	12.45
Jamaica	10 991	2 728	...	11	402 990	44	Storm (82%)	100.1
Mexico	1 964 375	107 801	8.2 (2008)	28	5 636 361	295	Storm (46%)	1.43
Panama	75 417	3 399	17.9 (2006)	10	61 580	60	Flood (90%)	13.26
Peru	1 285 198	28 221	17.8 (2007)	13	4 206 502	823	Flood (31%)	1.01
United States	9 522 552	308 798	...	113	20 093 698	3 154	Storm (55%)	1.20

... not available

Sources:
a) Encyclopaedia Britannica Online Encyclopaedia (21)
b) Pan American Health Organization (44)
c) World Bank (73)
d) Centre for Research on the Epidemiology of Disasters (11)
e) Pan American Health Organization estimate

Table III
Types of natural disasters, number of events, total affected population, people killed and selected examples, Americas, 2004-2008

Type of natural disaster*	Number of events (%)	Number of total affected population	Number of people killed	Selected examples
Drought	14 (3.0%)	1 520 990	4	Brazil 2007 1 000 000 total population affected Number killed: N/A Estimated damages: N/A
Earthquake	22 (4.7%)	749 759	645	Peru, 2007 658 331 total affected 593 killed US$600 million estimated in damages
Extreme Temperature	20 (4.2%)	3 024 070	427	Peru 2004 2 137 467 total affected 90 killed Estimated damages: N/A
Flood	170 (36.2%)	23 241 475	5 729	Haiti 2004 31 283 total affected 2 665 killed Estimated damages: N/A
Storm	190 (40.4%)	18 308 326	8 713	'Katrina', United States 2005 500 000 total affected 1 833 killed US$125 000 million estimated in damages
Volcano	14 (3.0%)	451 814	16	'Tungurahua', Ecuador 2006 300 013 total affected 5 killed US$150 million estimated in damages
Wildfire	18 (3.8%)	852 929	27	Paraguay 2007 125 000 total affected 8 killed US$30 million estimated in damages
Others	22 (4.7%)	290 969	335	
Total	470	48 440 332	15 896	

NA not available

Sources: Centre for Research on the Epidemiology of Disasters (11)

* Definitions of natural disasters according to the Emergency events database EM-DAT (12)

Drought: Long lasting event triggered by lack of precipitation. A drought is an extended period of time characterized by a deficiency in a region's water supply that is the result of constantly below average precipitation. A drought can lead to losses to agriculture, affect inland navigation and hydropower plants, and cause a lack of drinking water and famine.

Earthquake: The result of a sudden release of stored energy in the Earth's crust that creates seismic waves. They can be of tectonic or volcanic origin. At the Earth's surface they are felt as a shaking or displacement of the ground.

Extreme temperature: Could be heat wave, cold wave and extreme winter conditions defined by damage caused by snow and ice.

Flood: Significant rise of water level in a stream, lake, reservoir or coastal region

Storm: Could a tropical cyclone (e.g. hurricanes, typhoons), extra-tropical cyclone (winter storm) or a local/convective storm (e.g. thunderstorm, snowstorm/blizzard, tornado).

Volcano (volcanic eruption): All volcanic activity like rock fall, ash fall, lava streams, gases etc.

Wildfire: An uncontrolled burning fire, usually in wild lands, which can cause damage to forestry, agriculture, infrastructure, and buildings.

The total number of deaths due to natural disasters during this period was 15 896. Figure 2 shows the uneven distribution of casualties in time, 2004 being the deadliest year in the period. Of these casualties, 6 387 (39.9%) occurred in Haiti. The other countries that reported more than 100 fatalities per year (Fig. 3) were as follows:

- Brazil (101)
- Colombia (155)
- the Dominican Republic (181)
- Guatemala (329)

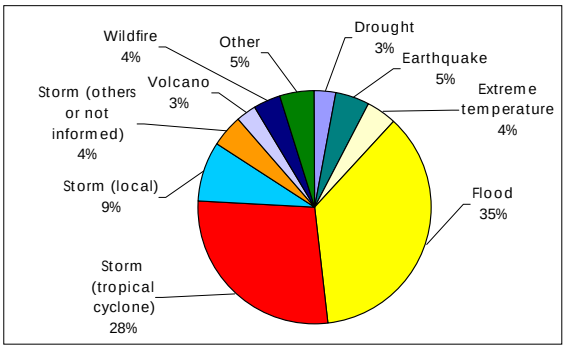

Figure 1
Number of events by type of natural disaster, Americas, 2004-2008
Source: Pan American Health Organization based on data from the Centre for Research on the Epidemiology of Disasters disaster list (11)

- Peru (165)
- the United States of America (631 cases).

A closer look at mortality rates highlight four countries that have rates close to or exceeding 2 deaths per 100 000 population (Fig. 4), namely:

- the Dominican Republic (1.9 deaths per 100 000 population)
- Granada (7.6 deaths per 100 000 population)
- Guatemala (2.5 deaths per 100 000 population)
- Haiti (13.4 deaths per 100 000 population.

This highlights the importance of natural disasters as a public health problem in the Caribbean and Central American subregions.

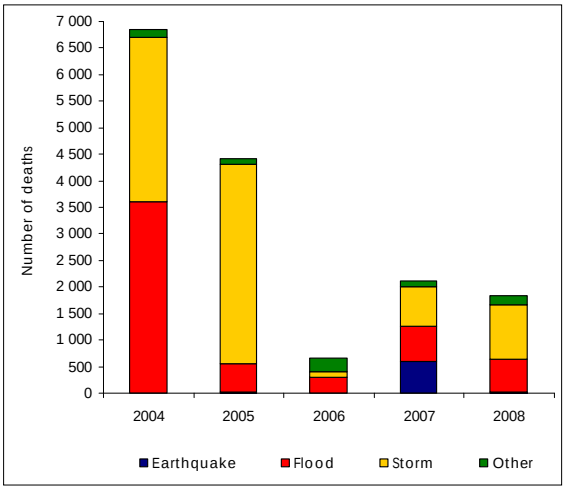

Figure 2
Number of deaths by type of natural disaster, Americas 2004-2008
Source: Pan American Health Organization based on data from the Centre for Research on the Epidemiology of Disasters disaster list (11)

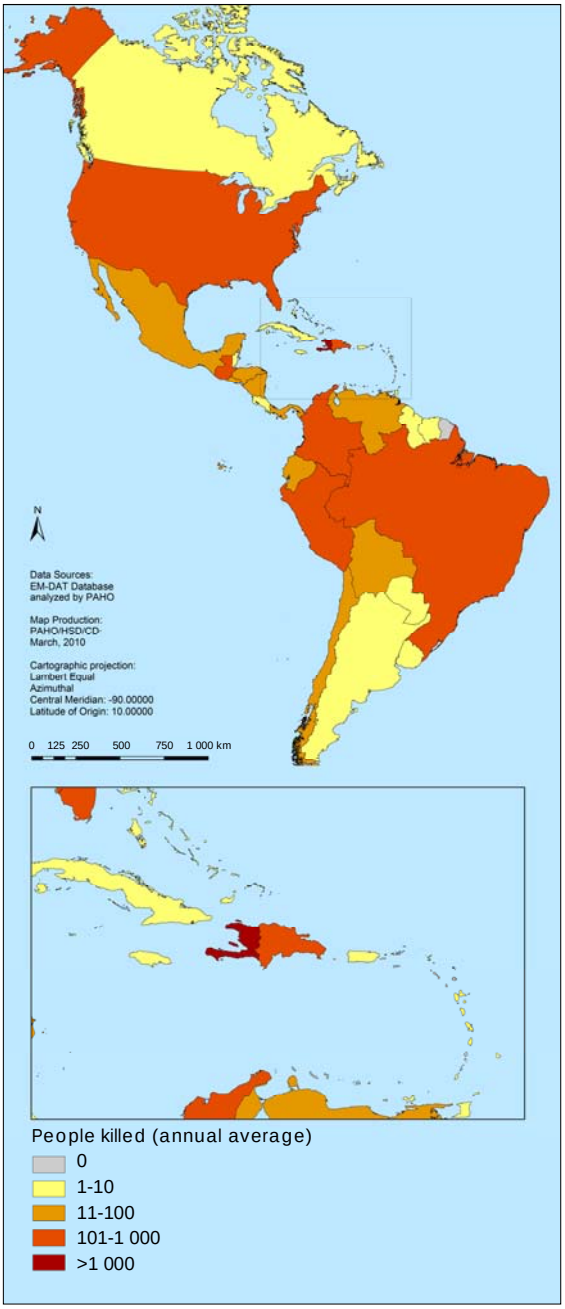

Figure 3
Number of people reported killed by natural disasters, Americas, 2004-2008
Source: Pan American Health Organization based on data from the Centre for Research on the Epidemiology of Disasters disaster list (11)

The mortality rate for Haiti is 39 times higher than the average for the region, which had an overall mortality rate caused by natural disasters of 0.34 per 100 000 population in the period. This high mortality rate is not due to a disproportionately high number of natural disasters. Haiti recorded 26 events during this

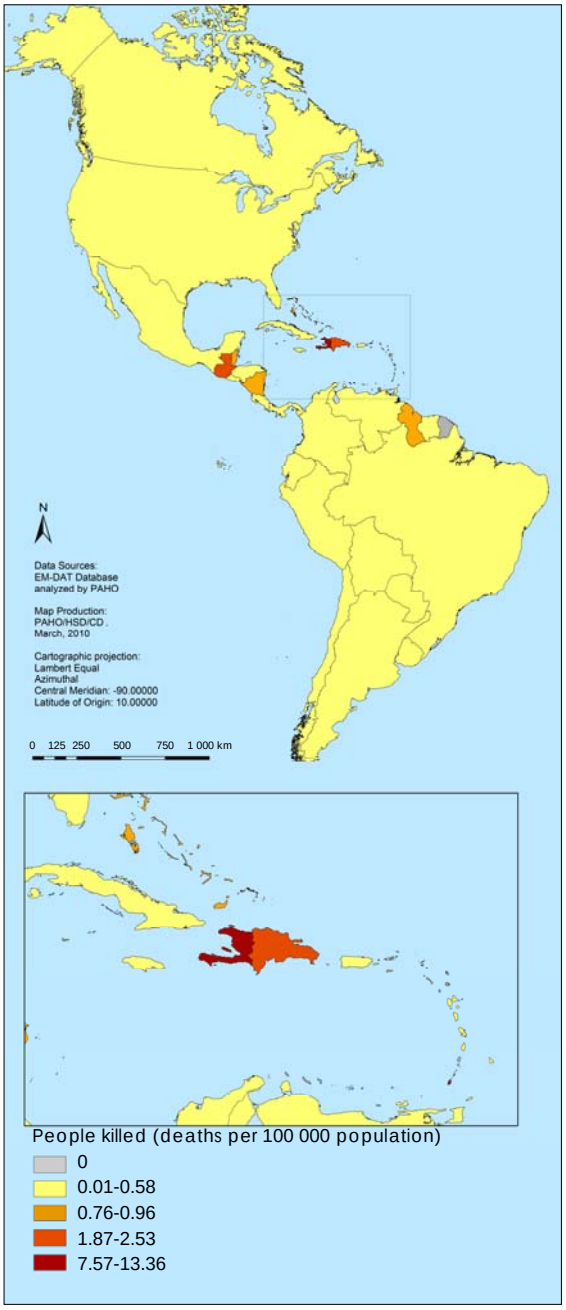

Figure 4
Mortality rate (per 100 000 population) by natural disasters, Americas, 2004-2008
Source: Pan American Health Organization based on data from the Centre for Research on the Epidemiology of Disasters disaster list (11)

period, comprising 5.5% of the total number of events; however these events caused 6 386 deaths or 40.1% of the total deaths due to natural disasters during this period.

Selected case studies of natural disaster and the contribution of veterinary public health

Guatemala

Guatemala is particularly vulnerable to natural disasters, as it sits on three tectonic plates, has 44 volcanoes, two oceans, two drainage basins and 38 basins. In 2008, the population of Guatemala totalled 14 million, with almost 50% living in rural areas. During the past decade, the country was hit by three major events that affected an estimated population of nearly 700 000 people, killing 1 102 (Table IV). Their cumulated economic impact is estimated at over US$2.7 billion. Besides tropical storms and volcanic eruptions, Guatemala suffered severe droughts in 2001 and 2009, resulting in major food crises.

Tropical cyclone and volcanic eruption in 2010

Tropical cyclone (hurricane) Agatha was the deadliest tropical storm in the eastern Pacific since Hurricane Pauline in 1997. It slammed into Guatemala's Pacific coast on 29 May, provoking torrential rains that triggered landslides and floods that left at least 165 people dead and another 113 people reported missing (Figs 5 and 6). A total of 21 departments and 200 municipalities (61% of the municipalities of the country) were affected to some degree, some suffering the combined effect of the Pacaya eruption and tropical storm Agatha. Some 3 934 houses were reportedly destroyed, 4 455 partially damaged and 7 690 slightly damaged.

An estimated 102 639 people were affected by the storm. The high number of people in shelters and health conditions of these shelters increased the risk and presence of diseases, such as respiratory infections, diarrhoea and of skin and ocular infections. There was a significant increase in the number of reported ophidic accidents (snake bites). There were increased risks of violence, child abuse, sexually transmitted diseases, mental diseases, unwanted pregnancies and reproductive health issues. Health services suffered

Table IV
Impact of selected natural disasters in Guatemala

Event	Year	Population affected	Deaths	Departments affected (out of 21)	Economic impact (US$ millions)
Tropical cyclone Mitch	1998	106 000	268	10	748.0
Tropical cyclone Stan	2005	475 000	669	15	988.3
Tropical cyclone Agatha and Volcano Pacaya	2010	102 639	165	21	982.0
Total	–	683 639	1 102	–	2 718.3

Source: Secretaría de Planificación y Programación de la Presidencia (SEGEPLAN) de Guatemala (26)

structural damage, including the cold chain used to supply 40 health services.

Volcano Pacaya, located some 30 km south-west of Guatemala City, erupted on 27 May, 2010. A violent eruption provoked stone and ash rains in many cities located north-west of the volcano, including Guatemala City, causing the temporary closure of the international airport. Heavy rainfall from tropical storm Agatha worsened the emergency situation, causing lahars, landslides and widespread flooding across the country. Four people were missing and at least 2 000 people were placed in shelters after four villages near the volcano were evacuated. An unknown number of animals were left behind in those communities. Animals were seen roaming, covered in ash with no food and water.

An estimated 30% of the animal population of the affected areas died, most were backyard chicken, cattle and horses that grazed on the pastures along the slopes of the volcano. The

Figure 5
Flood in Guatemala, 2010.
Photo: Presidency of Guatemala

Figure 6
People seeking supplies after the tropical storm, Guatemala, 2010
Photo: Presidency of Guatemala

combined events of the volcanic eruption and the tropical storm mainly affected the availability of food for production animals and pets (82). In the report published by the Government of Guatemala (26), the impact on the agriculture sector was evaluated at US$89 986 000, including the loss of backyard animals (poultry, pigs and small ruminants) and of production animals (bovines and poultry). Losses in egg production were estimated at US$235 000.

During the crisis, VPH workers focused on the following:

- the diagnosis, prevention and control of hantavirus and leptospirosis, with the provision of diagnostic kits for use in field conditions (rapid tests for both diseases) and specifically for leptospirosis, tests for use in hospitals (such as the enzyme-linked immunosorbent assay: ELISA), and in the

national reference laboratory (panel of reference strains, polyclonal antibodies)
- the inclusion of doxycycline in the list of priority medications
- purchase of rodenticide
- the design, printing and distribution of 50 000 leaflets on leptospirosis.

Additionally, the PAHO organised the despatch of a technical mission of leptospirosis experts from Nicaragua, a country that has developed a strong expertise in this field.

On the food safety side, the needs of the national reference laboratory were evaluated to respond to increased requests of laboratory support in case of outbreaks of foodborne diseases. Priority was given to health promotion, with the distribution of equipment for shelter kitchens, recommendations on the washing of hands and the WHO 'golden rules for safe food'.

Drought in 2009

In 2009, Guatemala was severely affected by atypical rainfall patterns caused by the El Niño weather phenomenon, which caused extensive losses, especially in hillside, subsistence and infra-subsistence agricultural production. Additionally, between July 2006 and July 2009, the increase in the cost of corn (43%) and in the price of beans (58%), resulted in a rise in cost of staple foods and reduced food access even further. Guatemala, a country with one of the highest rates of chronic malnutrition in the world and the highest in Latin America and the Caribbean (43% of children below 5 years of age are malnourished), saw a rapid increase in mortality due to acute malnutrition among children under five years of age, especially among infants under 6 months in the Dry Corridor (Guatemala's East Central Pacific departments). A first assessment conducted in nine departments of the country indicated a rate of 11% of acute malnutrition in children under five in the Dry Corridor, a rate of 14% of acute malnutrition in women of childbearing age and decreased food reserves in the households of small agricultural producers.

There was no formal evaluation of losses in the animal production and health sectors. As an indicator of what might be the impact of the drought in Guatemala, Mexico reported up to 75% of corn crop lost in the States of Puebla, Hidalgo, Aguascalientes, Michoacán, Guanajuato and Tlaxcala. The National Confederation of Farmer Organisations declared that the drought also led to the loss of 50 000 cattle.

Haiti – tropical cyclone, floods and earthquake

Haiti is the third largest country in the Caribbean. It occupies the western territory of the Island of Hispaniola, bordering the Dominican Republic. In 2008, Haiti totalled 10 million inhabitants, with 54%living below the international poverty line of US$1 per person per day (44). From 2004 to 2008, 26 natural disaster events were reported in the EM-DAT from Haiti; 15 of these events were storms (tropical cyclones), 10 were floods and 1 was drought. The 2005 hurricane season was especially intense (42, 43). There are two rainy seasons in Haiti, from April to June and from October to November. The hurricane season overlaps with the middle of the dry season (August to September), which means that Haiti is at risk of natural disasters most of the year.

The types of natural disasters that affect Haiti suggest that certain communicable zoonotic diseases could be endemic in the country, such as vector-transmitted diseases. For example, leptospirosis is very common after flooding. Leptospirosis is endemic in the country, but there is no surveillance system in place for the disease. Being one of many health priorities, the burden of this disease could be controlled. This topic could be the focus of technical cooperation in the field of VPH as part of a multidisciplinary approach in the preparation and response to outbreaks.

Human rabies transmitted by dogs is a priority in Haiti. In previous years, the country presented the highest number of human cases of rabies in the Americas. Due to the strong efforts of the national authorities, with the assistance of PAHO and others countries, such as the donation by Brazil of canine rabies vaccine, the epidemiological situation has improved considerably. However, the risk of rabid dog bites persists and the population's access to post-exposure prophylaxis remains

very important, particularly during emergency periods. In addition, it is important to pursue rabies control activities, such as mass vaccination campaigns of dogs and the development surveillance systems, as soon as possible after emergency phases.

In January 2010, an earthquake of 7.0 on the Richter scale occurred in Haiti. The epicenter was close of the capital Port-au-Prince (approximate population: 2 million inhabitants). This was a devastating natural disaster, the strongest earthquake recorded in 200 years in this country. Over 220 000 people were killed, 300 000 others were injured and 2 million lost their homes (63, 81). The human impact has been immense in a country already marked by a multitude of challenges (Figs 7 and 8). The international response to help Haiti was extensive and a great example of solidarity. The United Nations response to disasters is organised in clusters and the WHO is responsible for the health cluster that includes a comprehensive list of activities during the different phases. From the communicable zoonotic disease perspective, it is important to mention the continuation of activities against rabies after an earthquake. In Haiti, this included access to post-exposure prophylaxis for people who were bitten by dogs, provided by the Ministry of Public Health, as well as continuing mass dog vaccination campaigns that were underway at the time of the earthquake. The vaccination campaign of dogs, developed by the Ministry of Agriculture with the support of different partners, was one of the first activities that returned to normal after the disaster, completing the mass campaign with over 400 000 animals vaccinated.

Figure 7
Home destroyed by the earthquake, Haiti 2010
Photo: Pan American Health Organization

Figure 8
People waiting for medical care after the earthquake, Haiti, 2010
Photo: Pan American Health Organization

As leptospirosis is endemic in Haiti, the UN health cluster has placed special emphasis on enhancing the diagnostic capacity, surveillance and prevention of this disease, some cases of which have been detected post-earthquake, and are expected to increase given the conditions that prevail after the disaster (8).

Chile – earthquakes and other disasters

Chile is located in the south-west region of South America, occupying a long and narrow zone of land placed between the Pacific Ocean and the Andes. In 2008, Chile had approximately 17 million inhabitants, with 2.4% living below the international poverty line, the lowest percentage for Latin America (44, 73). From 2004 to 2008, the EM-DAT reported 13 events of natural disasters in Chile, including: floods (7), earthquakes (3), extreme temperatures (2), volcano eruptions (1) and storms (1).

In 2010, an earthquake that measured 8.8 on the Richter scale in some areas, occurred in Chile and was accompanied by a tsunami. This event affected six regions in the country with approximately 4 million inhabitants, half of whom suffered losses or damage to their homes. Furthermore, these disasters strongly affected the infrastructures of the country, such as schools, hospitals, bridges, roads, ports, airports, sewage systems and drinking

water, as well as the activities of public services. The number of deaths (504) was lower that feared on account of the intensity of the phenomenon (Figs 9 and 10).

The emergency response included the formation of interdisciplinary teams with full intervention of veterinarians who participated and still participate actively in the implementation of a response led by the regional health and local institutions in the area of environmental health. Teams continue to work to strengthen the monitoring of the water supply for human consumption, food safety and vector/rodent control, particularly in the localities where camps and villages were set up to shelter the victims. Furthermore, with the participation of local organisations and non-governmental organisations, the Chilean Medical Veterinary Association (*Colegio Médico Veterinario de Chile*), schools of veterinary medicine and others, developed local primary health care operations for pets, especially dogs and cats. This meant the administration of vaccines and drugs when necessary, as well as external and internal de-parasitisation, supply of food and delivery of recommendations to owners and caretakers of these animals that mainly wander freely in public spaces and on the streets.

Figure 9
Tsunami, Chile, 2010
Photo: Pan American Health Organization

No abnormal foodborne or zoonotic disease outbreaks were reported after the earthquake/tsunami occurred. The VPH activities performed in response to the natural disaster provided a valuable contribution to the maintenance of the public health during this situation.

Figure 10
Dogs on the streets after the earthquake, Chile, 2010
Photo: Pan American Health Organization

Nicaragua – tropical cyclones and floods

Nicaragua is one of the top five priority countries for PAHO. It is located in Central America, one of the subregions that is most vulnerable to natural disasters. The most well-known natural disaster in the last decade was hurricane Mitch which hit several countries of Central America and Mexico in 1998, affecting more than 2 million people. In Nicaragua alone, there were approximately 870 000 people affected, with 3 300 killed, and close to US$1 million in estimated damages (EM-DAT). From the communicable disease perspective, four outbreaks were reported in the same year. The leptospirosis outbreak after hurricane Mitch was very well documented by the Ministry of Health of Nicaragua. The data show a marked weekly increase in reported cases, with a cumulative total of 540 cases for the four weeks of November (38).

In 2008, Nicaragua had a population of 5.7 million, with 32% living below the international poverty line (44). From 2004 to 2008, eight of the nine events of natural disasters reported in the EM-DAT in Nicaragua were water-related (3 floods and 5 tropical cyclones). Among them were two major events in 2007, namely: a flood affecting 24 000 people and the tropical cyclone Felix, a wind storm that affected close to 200 000 people, killing 188. This cyclone pulled

down trees and palms in the savannah ecosystem, a natural habitat for common vampire bats (*Desmodus roduntus*). There were reports of an increase in the number of bat bites of humans, mostly in the displaced populations in vulnerable shelters. In the same year, a flood affected 24 000 people and mobile health 'brigades' were mobilised for integrated work to control dengue, malaria and leptospirosis. After the flood in October 2007, the number of cases of leptospirosis increased considerably, from an average of 1 case a week to 100 cases two weeks after the event (Fig. 11).

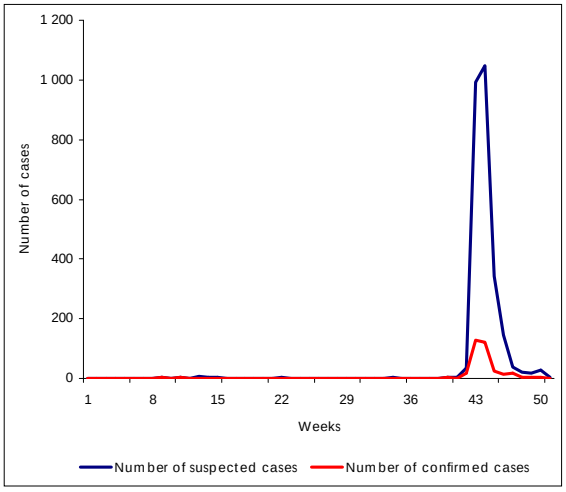

Figure 11
Human cases of leptospirosis post flood, Nicaragua, 2007
Source: Pan American Health Organization based on data from the Ministry of Health of Nicaragua (*Sistema Nicaragüense de Vigilancia Epidemiológica Naciona*: SISNIVEN)

In Nicaragua, leptospirosis prevention and control activities are conducted in the 17 units of the Local System of Integrated Assistance in Health of the Ministry of Health (*Sistema Local de Atención Integral en Salud*: SILAIS). Human cases with clinical symptoms that enter the health system are being tested for this disease (through a rapid test) and positive cases are treated rapidly. Samples are sent to the central laboratory to confirm diagnosis and identify the serovar using the ELISA. Epidemiological investigations and other activities linked to the control of the focus of infection, including vector control, are also developed during outbreaks and are usually associated with dengue and other communicable diseases. Leptospirosis activities are part of an intersectorial approach that includes the Ministry of Health. They are also part of the National Disaster Preparedness Plans for Natural Disasters.

Peru – different types of natural disasters

Peru is located in the Andean subregion, with a population estimated in 2008 at approximately 28 million, with 10.5% living below the international poverty line (44). From 2004 to 2008, the EM-DAT reported 13 events of natural disasters in Peru. The different types of disasters included the following: floods (4), earthquakes (3), extreme temperatures (winter conditions) (2), droughts (2), volcano eruption (1) and mass movement (wet). Among the events listed above was the 2007 earthquake in the Inca and adjacent departments, with approximately 700 thousand people affected, 593 killed and estimated damages amounting to US$ 600 million. Figure 12, based on a table reported by country authorities, shows the importance of the VPH-related activities during this event, with over 250 cases of dog bites in a country where rabies is present in some areas, over 200 cases of foodborne disease and more than 100 cases of people suffering from spider bites.

Discussion: contribution of veterinary public health to natural disaster preparedness and response

The participation of veterinarians in multidisciplinary teams that provide relief and assistance after natural disasters has been reported for decades, particularly in Italy (9, 10, 31, 45, 47, 71, 74). The WHO has also published several documents on this topic (4, 74, 76). These documents suggest that the role of VPH in disaster situations is to cope with devastating epidemics in humans and animals after the breakdown of usual services and community life (4). During the first training session on veterinary actions in disaster

situations organised by the European Centre for Disease Medicine in 1989 in San Marino, possible VPH actions by type of disaster and sanitary problems related to refugee camps were discussed (27). Specific VPH activities that have been recorded include the disposal of animal carcasses and waste, zoonoses prevention and control, re-establishment of food sanitation procedures and vector and pest control (31, 74).

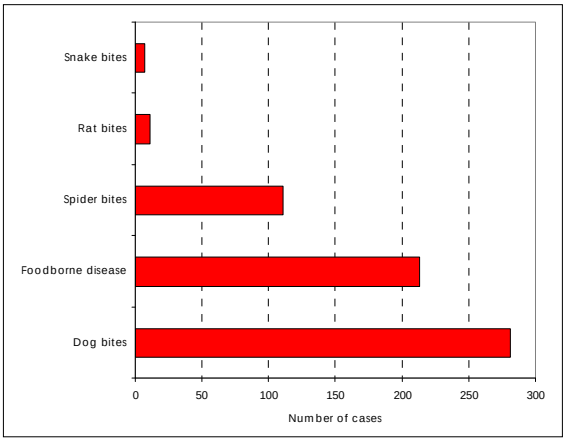

Figure 12
Number of tracer injuries post disaster, Provinces of Ica, Pisco, Chincha and Cañete, Peru, 2007
Sources: Pan American Health Organization based on data from the Ministry of Health (DGE/MINSA, Sala de Situación (23/09/07) (H. Chincha, Peru, personal communication)

In the past two decades however, this contribution of veterinarians to public health has not been actively documented. The First International congress of veterinarians in emergencies, organised in Montesilvano, Italy, in April 2010 (1), brought this important topic back onto the agenda at a crucial moment, as the world becomes more sensitive to the devastating impact of recent natural disasters and as the discussions progress on climate change and its possible influence on health. Including VPH activities in the civil protection system to manage non-epidemic emergency would be one of the phases for future contributions of this discipline in the management of natural disasters (6).

For the Americas, the magnitude of the data in terms of number of events and people affected and killed shows that natural disasters are a very important public health problem. Besides the loss of human lives and injuries, any disaster situation has the potential of increasing the risk of communicable diseases (39). In particular, from the point of view of VPH and communicable diseases, two major areas of technical cooperation could be suggested for the region, namely: reducing the risk of leptospirosis outbreaks and vector-borne diseases after floods or hurricanes (storms) because these constitute the majority of the events that occur in the region and improving food safety and other food chain issues that affect the population which represents an average of 12 million people every year who may be living in shelters or in areas suffering from disruptions and inadequate infrastructures. The most frequent VPH contributions to the control of communicable diseases after natural disasters in the Americas are as follows:

- prevention and control of zoonoses, principally leptospirosis, after floods and hurricanes, integrated with other vector-transmitted diseases
- prevention and assistance in case of animal bites to avoid rabies, as well as spider and snake bites
- food safety in displaced population camps, surveillance for human consumption and support to re-establish entire food chain in the affected areas
- work in collaboration with other teams involved in animal rescues and other sectors, mostly environmental.

Many others topics could be added, depending on the epidemiological situation of the country and the type of disaster as presented above in the regional case studies.

Flood and leptospirosis in integrated plans

Leptospirosis is an epidemic-prone zoonotic bacterial disease that is transmitted through contact with the urine of infected animals. This water-related disease occurs worldwide, in both rural and urban areas, developed and developing countries and mainly in tropical climates (14, 81). The association of floods with outbreaks of leptospirosis is well documented (3, 5, 22, 25, 30, 38, 60). An integrated approach

is necessary to tackle this issue, including surveillance and control in animal populations prior to the flooding period, timely case detection in humans, rapid tests and treatment of cases, identification of animal reservoirs, rodent control, risk communication and joint multidisciplinary training, which all require the intervention of both the public health and animal health sectors.

In areas prone to flooding, it is important to integrate the control of other vector-borne diseases, such as dengue, another epidemic-prone disease which, in many countries, is also managed by multidisciplinary teams. In this respect, VPH activities could be included in plans for disaster preparedness. According to the needs of each country, other actions could also be included in the plans, such as the treatment of animal bites (to avoid death from rabid or poisonous animals).

In some countries of the region, VPH activities are already part of the preparedness plans for natural disasters. In Brazil for example, the national plan for the preparation and response to disasters associated with floods includes a component devoted to leptospirosis and the control of other vectors and accidents with animals, such as snakes, spiders and scorpions (34). In Cuba, the VPH sector has been participating in this field for two decades (2, 10).

Special attention could be devoted to refugee camps and displaced populations, as in Haiti, where thousands of peoples are still living in tents. In these complex situations, the integrated vector control activities that usually include rats and mosquitoes could also incorporate other pests, such as lice and flies, to improve the quality of life in the camps (37).

Natural disasters and food safety

From the food safety perspective, preparedness and response plans require attention along the food chain from primary production to consumption, and this requires the involvement of VPH in collaboration with food safety, human, animal, plant and environmental health services. After natural disasters, the following issues require immediate attention:

- provision of safe food and water
- preventive food safety measures
- inspecting and salvaging food
- recognition and response to outbreaks of foodborne diseases
- risk communication and information on food safety (77).

For example, while agricultural production may be adversely affected by flooding associated with natural disasters, there may be areas where food can still be harvested or where food has been stored safely post harvesting and assessments should be conducted by food safety, VPH and phyto-sanitary services to establish measures that will reduce the risk of pathogens, hazardous chemicals, natural toxins etc. (e.g. delayed harvesting, heat treatment) or to ensure stock disposal (77). Inspection services play a key role in the protection of intact foods against exposure to sources of contamination and spoilage (e.g. in warehouses that have been flooded). In the aftermath of natural disasters, it is necessary to inspect food industries, slaughterhouses, markets and catering establishments to ensure safe handling and that damaged or contaminated foods are not marketed. This requires interdisciplinary teams that include VPH experts.

It is vital to detect food, water, vector-borne and zoonotic disease outbreaks as early as possible so as to limit their spread. Communication between human and veterinary epidemiological services, food safety authorities, industry, emergency medical response agencies and quarantine and customs agencies is essential to ensure the timely treatment of exposed people or to recall contaminated food from circulation. The effectiveness of the response depends to a great extent on preparedness, the capacities for investigation and verification and coordination between the relevant government bodies and other agencies that contribute to managing the public health consequences.

While not the focus of this article, it is also important to mention that during disasters, a

large number of animals usually die. Ensuring the survival of those animals that are rescued is a concern for many institutions and groups (1, 24, 71, 82). The zoonoses and food safety teams could work in collaboration with animal rescue teams to provide surveillance, vaccination for prevalent diseases, sanitation, disposal, food storage and many other aspects.

Priority countries for veterinary public health collaboration on natural disasters

The Americas are very prone to natural disasters, particularly those caused by storms (including hurricanes) and floods. In the present analysis, it is evident that Haiti presents the highest risk of natural disaster in the region of the Americas. This country has more events (hazards) by territory area and also an average mortality by natural disasters rate that is 30 times greater than the average of the region over the five years studied. The vulnerability of the country is very high, not only as reflected in the number of human losses (almost haft of the total for the region in this period) but also in the effects on infrastructures, as shown in the number of houses, schools, hospitals and other facilities that are lost after a natural disasters (44, 81). Haiti, with over 50% of the population living below the poverty line, is one of PAHO's priority countries for technical cooperation and needs to continue receiving international support not only for humanitarian purposes, but also to improve their development as a nation.

The Dominican Republic, which shares the Hispaniola Island with Haiti, is another country that has a high risk of natural disasters. In comparison to Haiti, the Dominican Republic has a lower poverty rate. In addition, the Dominican Republic has a preparedness plan for natural disasters that involves several sectors (52). For the Hispaniola Island and mostly Haiti, special attention needs to be given to a preparedness plan for natural disaster and the participation of VPH could be relevant for all aspects mentioned in this article.

Most of the countries of Central America presented 10 or more events (hazards) during the period under analysis, suggesting that this risk could be considered a priority for this subregion. The vulnerability varies between the countries depending of many factors, including poverty and infrastructure. The types of natural disaster also vary, as shown in the case study of Guatemala and have presented different challenges in recent years. Some countries of the Caribbean, such as Cuba and Jamaica, were affected by many events without high numbers of casualties, which suggests an effective level of preparedness.

For countries with larger territorial areas, a disaggregated analysis is suggested to identify the areas of higher risk ('hotspots') for different types of natural disasters, such as floods, and to analyse possible VPH activities in the preparedness plans.

Conclusions and recommendations

On many occasions, PAHO VPH professionals have participated in multidisciplinary teams to develop technical cooperation activities in support of a country's response to an emergency, since around 70% of the emergency events are related to the animal/ human health interface (15, 51, 58). The participation of VPH in natural disasters is very important and could be better utilised.

Greater communication and cooperation among human health, VPH and environmental health services is particularly valuable in the prevention of and response to the impact of disasters which often enhance the presence of disease, including food-, water-, vector-borne and zoonotic diseases. In this context, the 'One World, One Health' concept is being promoted at the international level (36).

When natural disasters strike, VPH actions that include food safety are critical public health interventions that have too often been neglected. Provisions should also be made to re-establish veterinary services and food safety systems in the reconstruction phase in the aftermath of natural disasters. Countries

should develop and update their disaster preparedness and response plans to ensure adequate consideration of food safety management and VPH issues in those situations. Developing and ensuring the capacity to implement such plans may require investment in trained human resources and in facilities (59).

Responding effectively to the needs of a disaster-affected population requires a communicable disease risk assessment (69, 81). Vector-borne disease surveillance in areas at high risk of natural disasters is very important. The identification of these potential risk areas ('hotspots'), mostly at risk of flooding, is a component that should be included in the integrated actions preparedness plan.

The key to effective disaster preparedness and response is the active participation of all relevant individuals and organisations at every level – community, provincial, national and international. This multi-sectoral approach means that many organisations, including animal health and production and food-related organisations, accept clearly defined responsibilities and the need to coordinate their efforts. Without such involvement and commitment, disaster preparedness and response become fragmented, inefficient and poorly coordinated (75).

At the international level, priorities for action include strengthening preparedness for effective response through the following:

- expanded contingency planning, especially in areas prone to flooding, windstorms or drought, and promotion of prevention and adaptation in the rehabilitation phases
- develop more flexible funding mechanisms at the international level that allow development and humanitarian resources to be invested in preparedness (23, 59, 80).

Contingency plans, including trained human resources and the necessary infrastructure to respond rapidly and efficiently to disasters, are of particular importance (24, 72).

Changing climate patterns have increased the urgency to invest in disaster risk reduction, preparedness and response plans. These plans should address food safety risks in the aftermath of natural disasters along the entire food chain (59). This requires inter-sectoral assessments of national infrastructural and operational capacity building needs for emergency preparedness and response. These plans should be developed within the framework of planned climate change adaptation strategies for food and nutrition security and safety.

During natural disasters and humanitarian crises, proper risk communication is the most effective tool to ensure the timely provision of information to the public on vector-, food-, waterborne and zoonotic risks and the actions that need to be taken to minimise those risks. VPH services play an essential role in risk communication on the human-animal interface.

Development and relief agencies have long recognised the important role played by data and information in mitigating the impacts of disasters on vulnerable populations. Systematic collection and analysis of these data provides invaluable information to governments and agencies responsible for relief and recovery activities. It also participates in the integration of health components into development and poverty alleviation programmes.

Major recommendations for VPH related to natural disasters with the focus on communicable diseases include the following:

- participation in the preparedness plan with multidisciplinary and multi-sector teams
- identification of natural disaster 'hotspots' (high-risk areas)
- provision of support to countries for risk assessments in previously high-risk areas of natural disasters such as flooding and support in regard to local preparedness
- development of inter-programmatic guidelines
- multidisciplinary training for different levels (professional and middle level)
- share best practices among countries
- solidarity among people (disciplines and geographic areas).

To support the VPH participation in the preparedness phases, plans to mitigate natural

disasters may include the analysis of types of disaster and related communicable diseases, the preparation of multidisciplinary teams, training utilising a comprehensive approach and also training outside universities for professionals, such as technicians or inspectors in topics related to natural disasters that include VPH aspects, mostly for areas of lower income.

Many activities have been performed in the last few decades that illustrate the role of VPH in natural disasters. The countries in the Americas have considerable experience, as have other countries outside the region, such as Italy, which would be of great value to the Americas. An important opportunity of south-south cooperation among countries, with the support of international organisations, could also be initiated on this topic.

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